



Postdeployment Hospitalizations among Service Members Deployed in Support of the Operations in Iraq and Afghanistan

***T. C. Smith
C. A. LeardMann
B. Smith
I. G. Jacobson
M. A.K. Ryan***



Naval Health Research Center

Report No. 07-26

Approved for public release; distribution is unlimited.

***Naval Health Research Center
140 Sylvester Road
San Diego, California 92106***

Postdeployment Hospitalizations Among Service Members Deployed in Support of the Operations in Iraq and Afghanistan

TYLER C. SMITH, MS, PhD, CYNTHIA A. LEARDMANN, MPH, BESA SMITH, MPH, PhD, ISABEL G. JACOBSON, MPH, AND MARGARET A.K. RYAN, MD, MPH

PURPOSE: There is significant public and veteran concerns over the impact of military deployments to Iraq and Afghanistan on veterans' health. This study investigates morbidity among deployers by uniquely comparing after-deployment hospitalizations to before-deployment hospitalizations and hospitalizations among nondeployers.

METHODS: To compare after-deployment with before-deployment rates of morbidity, we examined active-duty military personnel who deployed for the first time in support of the current conflicts in 2003 or 2004 and had at least 12 months of service before deployment. We also compared the after-deployment hospitalizations to hospitalizations of personnel serving on active duty from May 2002 through May 2004 without a deployment from September 2001 through August 2006. This historical prospective investigation utilized Cox's proportional hazards time-to-event modeling. Hospitalizations for any cause and hospitalizations based on 14 broad diagnostic categories were examined.

RESULTS: After adjusting for demographic and occupational variables, the after-deployment risk for any-cause hospitalization was greater in comparison with before-deployment (hazard ratio, 1.57; 95% CI, 1.48–1.66) but lower in comparison with nondeployers (HR, 0.95, 95% CI, 0.92–0.98).

CONCLUSIONS: Active-duty service members have an increased risk of hospitalization after deployment compared with before deployment but a lower risk when compared with nondeployers. *Ann Epidemiol* 2009;19:603–612. © Published by Elsevier Inc.

KEY WORDS: Afghanistan, Hospitalization, Iraq, Military medicine, Military personnel, Veterans.

INTRODUCTION

In the decade after the 1991 Gulf War, more than \$1 billion was spent researching multisymptom illnesses reported by some returning veterans (1). One of the first large epidemiologic studies after the 1991 Gulf War investigated the morbidity of deployed and nondeployed veterans measured by hospitalization (2), and it found no excess of unexplained illness among active-duty members within 2 years after war. Other epidemiologic investigations that used hospitalization

to indicate severe morbidity followed, including in-theater hospitalizations (3), Department of Veterans Affairs and civilian hospitalizations (4), hospitalizations for unexplained illnesses (5), mental health (6), and specific health conditions (7, 8). Hospitalizations also were used to investigate morbidity in subpopulations, including self-selected Gulf War Health Registry participants (9), coalition personnel (10, 11), and personnel possibly exposed to Kuwaiti oil well-fire smoke or nerve agents at Khamisiyah, Iraq (3, 12–14). This research on 1991 Gulf War veterans' health did not reveal etiologies for increased symptom reporting or a clear case definition of "Gulf War illness," which is concerning in light of the current combat operations in the region.

The health of returning US military members after combat operations in Iraq and Afghanistan is an important public and military health concern. Research to date suggests a high prevalence of mental health symptoms in returning veterans (15–18) and increases in unhealthy behaviors (19–21); however, research of other health outcomes is sparse. The objectives of this exploratory investigation were to compare after-deployment and before-deployment hospitalizations and to compare after-deployment hospitalizations to hospitalizations of those not deployed during the

From the Department of Defense Center for Deployment Health Research, Naval Health Research Center, San Diego, CA.

Address correspondence to: Dr. Tyler C. Smith, DoD Center for Deployment Health Research, Naval Health Research Center, 140 Sylvester Road, San Diego, CA 92106-3521. Tel.: 619-553-7593; fax: 619-553-7601. E-mail: Tyler.C.Smith@med.navy.mil.

This work represents report 07-26, supported by the Department of Defense, under work unit no. 60002. The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of the Army, Department of the Air Force, Department of Defense, or the US Government. This research has been conducted in compliance with all applicable federal regulations governing the protection of human subjects in research and under IRB Protocol NHRC.2004.0034.

Received January 16, 2009; accepted May 10, 2009.

Selected Abbreviations and Acronyms

DoD = Department of Defense
ICD-9-CM = *International Classification of Diseases, Ninth Revision, Clinical Modification*
HR = hazard ratio
CI = confidence interval

same time period. By comparing in this way, it was hoped that an examination of hospitalizations would provide preliminary indications of health problems secondary to deployment.

METHODS**Population and Data Sources**

The study population included regular, active-duty military personnel who deployed for the first time in support of the wars in Iraq and Afghanistan from January 1, 2003, to December 31, 2004, returned from deployment before July 1, 2005, and had at least 12 months of service before deployment. At least 1 year of after-deployment follow-up time was achieved by excluding those who deployed again within the year of returning from deployment. Individuals who deployed for a second time after the 1-year period were retained for these analyses. For the second objective, the nondeployed comparison population included regular, active-duty service members who were on rosters as of May 2003 (the median first month of deployment for deployers included in this study) and did not deploy in support of the wars in Iraq and Afghanistan between September 2001 and September 2006. For comparison, nondeployers had to have at least 12 months of active-duty service both before and after May 2003. To account for demographic differences, nondeployed personnel were frequency matched to deployed personnel on sex and age. Demographic, occupational, and deployment data were obtained from electronic military records and included sex, birth date, education, marital status, race/ethnicity, pay grade, service branch, occupation, and deployment dates.

Hospitalization data were obtained from the Standard Inpatient Data Record and Health Care Service Record databases. The former contains one record for each inpatient encounter for care at a Department of Defense (DoD) hospital worldwide with up to eight *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) diagnoses (22). The latter contains one record billed to the DoD for each visit to a civilian hospital with up to 10 ICD-9-CM diagnoses. For these analyses, only the first hospitalization for the targeted diagnosis or group of diagnoses was included.

Outcomes

To examine the association between hospitalization and deployment, before- and after-deployment hospitalizations were compared among deployers. After-deployment hospitalizations from January 1, 2003, to December 31, 2005, were compared with before-deployment hospitalizations of the same individuals. To ensure new accessions were well-represented, the before-deployment hospitalization period included only 1 year immediately preceding deployment. To capture the broader after-deployment hospitalization experience, 2 years immediately after deployment comprised the after-deployment period.

Additionally, after-deployment hospitalizations of deployers were compared with hospitalizations of nondeployers during the same time frame. After-deployment hospitalizations from January 1, 2003, to December 31, 2005, were compared with hospitalizations of nondeployers from June 2, 2004, to December 31, 2005. The observation period for the nondeployed group was chosen, a priori, based on the median deployment date and the mean length of follow-up time for deployers. For both objectives, separate models were used to examine hospitalization for any cause, excluding childbearing reasons, and hospitalization as the result of causes within 14 major ICD-9-CM diagnostic categories.

Statistical Analyses

Univariate analyses were used to examine associations between any-cause after-deployment hospitalization and demographic, occupational, and deployment variables. Multicollinearity was examined using regression diagnostics. Cox's proportional hazards time-to-event modeling was used to calculate adjusted hazard ratios and 95% confidence intervals. A sandwich covariance method was used to account for the within subject correlation in the before- and after-deployment comparison (23). Subjects were classified as having an event if hospitalized for any cause in the main model or hospitalized for causes in each of the 14 categories for the subsequent models. For deployers, follow-up time for the before-deployment period began 1 year before deployment and ended with the date of hospitalization or the day before deployment, whichever occurred first. Follow-up time for the after-deployment period began the day after returning from deployment and ended with one of the following events, whichever occurred first: hospitalization, separation from service, end of the 2-year period after returning from deployment, first day of a second deployment occurring at least 1 year after returning from first deployment, or December 31, 2005. For nondeployers, follow-up time for hospitalizations began June 2, 2004, and ended with one of the following events, whichever occurred first: hospitalization, separation from service, or December 31, 2005. For the 14 diagnostic categories that

were significantly associated with deployment, frequencies of the three most common diagnoses were examined.

A subanalysis was performed to investigate rates of hospitalization during periods that were not directly before or after deployment. With the use of a subset of the deployed sample, hospitalizations 6 to 12 months before deployment (excluding the 6 months immediately before deployment) were compared with hospitalizations 18 to 24 months after deployment (excluding the 18 months immediately after deployment). This subset included active-duty personnel who did not deploy a second time in the 18 months after their first deployment. Cox's proportional hazards time-to-event modeling with a sandwich covariance method was used to account for within-subject correlation. Subjects were classified as having an event if they were hospitalized for any cause. Follow-up time for the before-deployment period was calculated from 1 year before deployment until hospitalization or 6 months before deployment, whichever occurred first. Follow-up time for the after-deployment period was calculated from 18 months after returning from deployment, until hospitalization, separation from service, 2 years after returning from deployment, the first day of a subsequent deployment, or December 31, 2005, whichever occurred first. All data analyses were completed with the use of SAS (Version 9.1, SAS Institute, Inc., Cary, NC). Research was conducted in compliance with all applicable federal regulations governing the protection of human subjects (Protocol NHRC.2004.0034).

RESULTS

Nearly 1.4 million US service members deployed in support of the wars in Iraq and Afghanistan from September 2001 to August 2006. Of these, 292,354 were regular active-duty personnel deployed between January 2003 and December 2004, who had at least 12 months of service preceding deployment, returned from deployment by July 1, 2005, did not deploy a second time within the year after first deployment, and had complete demographic, occupational, and deployment data. Approximately 400,000 individuals were regular, active-duty service members from May 2002 through May 2004, did not deploy from September 2001 to August 2006, and had complete demographic data. Of those, 232,095 were frequency-matched to deployers based on sex and age.

After frequency matching, deployed personnel were more likely to be in the Army or Marine Corps and be combat specialists compared to nondeployed personnel (Table 1). Among deployers, characteristics of personnel at increased adjusted risk of after-deployment hospitalization included female, older, less educated, white non-Hispanic, not married, Army service members, enlisted, combat specialists, and those deployed <90 days (Table 2).

TABLE 1. Characteristics for active-duty service members deployed and not deployed in support of the wars in Iraq and Afghanistan, after frequency matching for sex and age

Characteristics	Deployers (n = 292,354), ^a % ^c	Nondeployers (n = 232,095), ^b % ^c
Sex		
Male	89.1	89.1
Female	10.9	10.9
Age, yrs		
17–23	39.8	39.8
24–29	27.6	27.6
30–36	18.1	18.1
> 36	14.6	14.6
Education		
High school diploma or less	86.3	83.7
More than high school diploma	13.7	16.3
Race/ethnicity		
White non-Hispanic	61.9	64.8
Black non-Hispanic	20.9	19.9
Other	17.2	15.3
Marital		
Married	51.7	52.7
Not married	48.3	47.4
Service branch		
Army	46.8	24.4
Air Force	15.7	29.7
Navy/Coast Guard	19.2	34.1
Marine Corps	18.4	11.8
Pay grade		
Officer	6.2	6.7
Enlisted	93.8	93.3
Length of deployment ^d		
<90 days	22.4	NA
91–180 days	39.9	NA
181–270 days	15.4	NA
> 270 days	22.3	NA
Occupational category		
Combat specialists	24.7	15.8
Electrical repair	8.9	12.1
Communications/intelligence	9.1	9.5
Health care specialists	5.6	9.2
Other technical	3.0	2.9
Functional support specialists	13.9	18.9
Electrical/mechanic	20.0	20.8
Craft workers	3.8	2.9
Service and supply handlers	11.0	7.9

NA = not available.

^aIncludes active-duty service members with 1 year of previous service and complete demographic data who deployed in support of the wars in Iraq and Afghanistan for the first time between January 1, 2003, and December 31, 2004, and returned before July 1, 2005.

^bIncludes active-duty service members not deployed in support of the wars in Iraq and Afghanistan between September 11, 2001, and August 31, 2006, with 1 year active-duty service before and after May 2003, complete demographic data in May 2003, and frequency matched to the deployers based on sex and age.

^cPercentages may not add to 100 because of rounding.

^dLength of first deployment in support of Operations in Iraq or Afghanistan.

TABLE 2. After-deployment hospitalization among 292,354 personnel deployed in support of the wars in Iraq and Afghanistan between January 1, 2003, and returning home by July 1, 2005

Characteristics	No. hospitalized After deployment	Percent	HR	95% CI
Sex				
Male	12,038	4.6	1.00	
Female	1,925	6.0	1.37	1.30–1.44
Age, yrs				
17–23	5,311	4.6	1.00	
24–29	3,613	4.5	0.94	0.90–0.99
30–36	2,702	5.1	1.03	0.98–1.09
> 36	2,337	5.5	1.32	1.25–1.41
Education				
High school diploma or less	12,205	4.8	1.00	
More than high school diploma	1,758	4.4	0.93	0.87–0.99
Race/ethnicity				
White non-Hispanic	8,772	4.9	1.00	
Black non-Hispanic	2,991	4.9	0.85	0.82–0.89
Other	2,200	4.4	0.86	0.82–0.90
Marital				
Married	7,333	4.9	1.00	
Not married	6,630	4.7	1.07	1.03–1.11
Service branch				
Army	8,040	5.9	1.00	
Air Force	1,721	3.8	0.49	0.46–0.52
Navy/Coast Guard	2,057	3.7	0.51	0.48–0.53
Marine Corps	2,145	4.0	0.69	0.65–0.72
Pay grade				
Officer	653	3.6	1.00	
Enlisted	13,310	4.9	1.73	1.57–1.91
Length of deployment ^a				
< 90 days	3,703	5.6	1.00	
91–180 days	4,971	4.3	0.86	0.82–0.90
181–270 days	2,059	4.6	0.82	0.78–0.87
> 270 days	3,230	5.0	0.80	0.76–0.84
Occupational category				
Combat specialists	3,651	5.1	1.00	
Electrical repair	1,036	4.0	0.80	0.75–0.86
Communications/intelligence	1,137	4.3	0.83	0.78–0.89
Health care specialists	955	5.8	1.05	0.97–1.13
Other technical	385	4.3	0.78	0.70–0.87
Functional support specialists	1,887	4.6	0.82	0.77–0.87
Electrical/mechanic	2,704	4.6	0.90	0.85–0.94
Craft workers	526	4.7	0.98	0.89–1.07
Service and supply handlers	1,682	5.2	0.96	0.90–1.02

^aLength of first deployment in support of the operations in Iraq and Afghanistan.

After-deployment risk for any-cause hospitalization was greater than before-deployment risk for any-cause hospitalization (hazard ratio [HR], 1.57; 95% confidence interval [CI], 1.48–1.66), and for hospitalization in all 14 broad ICD-9-CM categories, after adjusting for demographic and occupational characteristics (Table 3). There was a > 40% increased risk of after-deployment hospitalization compared with before-deployment hospitalization among all 14 categories. The greatest after-deployment hospitalization rates were among those diagnosed in the injury and poisoning category (11.85/1000 person-years), mental disorders (10.37/1000 person-years), and musculoskeletal system diseases (8.34/1000 person-years).

There was a reduced risk for any-cause hospitalization among deployers when compared with nondeployers (HR, 0.95; 95% CI, 0.92–0.98), and for hospitalization in 10 broad ICD-9-CM categories, after adjusting for demographic and occupational characteristics (Table 4). Only the injury and poisoning category indicated an increased risk in deployers when compared with nondeployers.

The three most common three-digit after-deployment diagnoses accounted for at least half of the hospitalizations in 7 of the 14 categories and at least 29% of the hospitalizations in another 6 categories (Table 5). Only the injury and poisoning category was not well explained by the most common diagnostic codes (12.5%). The subanalysis

TABLE 3. Adjusted HRs for after-deployment hospitalization compared with before-deployment hospitalization deployment status among active-duty service members

ICD-9-CM codes	Major diagnostic categories	Predeployment, ^a n (rate ^b)	Postdeployment, n (rate ^b)	HR ^c	95% CI ^c
001–139	Any cause	7,281 (25.24)	13,963 (38.08)	1.57	1.48–1.66
140–239	Infections and parasitic diseases	652 (2.23)	1,334 (3.54)	1.64	1.49–1.82
240–279	Neoplasms	190 (0.65)	627 (1.66)	2.41	2.03–2.86
	Endocrine, nutritional, and metabolic diseases	430 (1.47)	1,348 (3.58)	2.32	2.07–2.60
280–289	Blood diseases	395 (1.35)	973 (2.58)	1.78	1.57–2.02
290–319	Mental disorders	1,250 (4.28)	3,889 (10.37)	2.56	2.39–2.74
320–389	Nervous system diseases	248 (0.85)	858 (2.28)	2.79	2.40–3.23
390–459	Circulatory diseases	491 (1.68)	1,606 (4.27)	2.43	2.18–2.71
460–519	Respiratory system diseases	768 (2.63)	1,407 (3.74)	1.47	1.34–1.61
520–579	Digestive system diseases	1,526 (5.23)	2,816 (7.50)	1.46	1.36–1.56
580–629	Genitourinary system diseases	702 (2.40)	1,426 (3.79)	1.58	1.43–1.74
680–709	Skin diseases	485 (1.66)	920 (2.44)	1.52	1.35–1.71
710–739	Musculoskeletal system diseases	957 (3.28)	3,129 (8.34)	2.55	2.36–2.75
780–799	Symptoms, signs and ill-defined conditions	1,614 (5.53)	3,073 (8.19)	1.47	1.38–1.57
800–999	Injury and poisoning	2,104 (7.22)	4,430 (11.85)	1.82	1.72–1.92

^aReference group.

^bNumber of events per 1000 person-years.

^cHR, 95% CI adjusted for sex, age, highest education level, race, marital status, service branch, pay grade, and occupation.

comparing the 6 to 12 months preceding deployment to the 18 to 24 months after deployment revealed that the increased risk of any-cause after-deployment hospitalization persisted after excluding the 6-month period immediately before and the 18-month period after deployment (HR, 1.37; 95% CI, 1.28–1.47).

The before-deployment monthly hospitalization rate for deployers ($n = 292,354$) was approximately 0.22% per month and decreased precipitously during the 5-month period preceding deployment (Fig. 1). After-deployment rates were approximately 0.36% per month. The overall hospitalization rates for service members included in the subanalysis were slightly lower for before deployment (0.19% per month) and after deployment (0.33% per month) compared with the larger sample of deployers. Although the after-deployment hospitalization rates for the subanalysis began much lower than the larger deployed sample (Fig. 1), rates began to converge 11 months after deployment and remained uniform throughout the remaining time period. The mean monthly hospitalization rate for active-duty deployers and nondeployers combined during the same 3-year period (January 2002 to December 2005) was 0.32%; slightly lower than the after-deployment rates among those who deployed.

DISCUSSION

For nearly a decade, the wars in Iraq and Afghanistan have required large numbers of US military members to deploy

numerous times for prolonged periods, raising concern over the health of service members returning from deployment. Military combat deployments are complex and diverse, with health consequences documented after each large-scale conflict (24, 25). This exploratory analysis describes a broad range of increased after-deployment hospitalizations among US military personnel deployed in support of the wars in Iraq and Afghanistan.

Demographic and occupational risk factors associated with after-deployment hospitalization, including older age, enlisted status, Army service, and female gender, have been documented (2–4, 9, 13, 26). Interestingly, those deployed for <90 days had the greatest adjusted risk for after-deployment hospitalization. This finding may be attributable to deployment-related injuries severe enough to require evacuation. After removing this subgroup of short-term deployers from the analysis, further investigation found consistent overall risk of after-deployment hospitalization (data not shown).

It is difficult to rationalize a systematic increase in all 14 broad diagnostic categories being caused by a unique deployment-related exposure. Findings may be better explained by practical and procedural health-care utilization issues. First, some personnel may delay care until return from deployment (27) because of decreased access to care while they are deployed. Others, who have been injured during deployment, may return to military hospitals for extensive follow-up. Hospitals receiving personnel injured during deployment may, in the process of routine diagnostic efforts, screen for diseases that would not ordinarily be identified in nonhospitalized or healthy individuals. However, our subanalysis,

TABLE 4. Adjusted HRs of after-deployment hospitalization of active-duty service members deployed in support of the wars in Iraq and Afghanistan compared with active-duty service members not deployed

ICD-9-CM codes	Major diagnostic categories	Nondeployed, ^a n (rate ^b)	Deployed, n (rate ^b)	HR ^c	95% CI ^c
	Any cause	10,472 (34.47)	13,963 (38.08)	0.95	0.92–0.98
001–139	Infections and parasitic diseases	951 (3.06)	1,334 (3.54)	0.99	0.91–1.08
140–239	Neoplasms	553 (1.78)	627 (1.66)	0.83	0.74–0.94
240–279	Endocrine, nutritional, and metabolic diseases	1,490 (4.80)	1,348 (3.58)	0.71	0.65–0.77
280–289	Blood diseases	829 (2.67)	973 (2.58)	0.87	0.79–0.96
290–319	Mental disorders	3,006 (9.71)	3,889 (10.37)	0.93	0.88–0.98
320–389	Nervous system diseases	709 (2.28)	858 (2.28)	0.91	0.82–1.01
390–459	Circulatory diseases	1,647 (5.31)	1,606 (4.27)	0.72	0.67–0.77
460–519	Respiratory system diseases	1,231 (3.97)	1,407 (3.74)	0.83	0.76–0.90
520–579	Digestive system diseases	2,516 (8.13)	2,816 (7.50)	0.85	0.80–0.90
580–629	Genitourinary system diseases	1,190 (3.83)	1,426 (3.79)	0.87	0.81–0.95
680–709	Skin diseases	605 (1.95)	920 (2.44)	1.10	0.99–1.23
710–739	Musculoskeletal system diseases	2,565 (8.29)	3,129 (8.34)	0.81	0.76–0.85
780–799	Symptoms, signs and ill-defined conditions	2,643 (8.54)	3,073 (8.19)	0.86	0.81–0.90
800–999	Injury and poisoning	2,726 (8.81)	4,430 (11.85)	1.12	1.07–1.18

^aReference group.^bNumber of events per 1000 person-years.^cHR, 95% CI adjusted for sex, age, highest education level, race, marital status, service branch, pay grade, and occupation.

designed to address these issues, found an increased risk of hospitalization 18 to 24 months after deployment compared with 6 to 12 months before deployment suggests that some chronic, ongoing health concerns persist even after 18 to 24 months following deployment. In another subanalysis, reducing the follow-up time of hospitalizations to 1 year after deployment found very consistent results with the 2-year follow-up. Investigation of personnel separating from active-duty service found a greater adjusted risk of after-deployment hospitalization among those leaving active service. More longitudinal investigation of these personnel is necessary to determine resiliency or persistent health problems associated with deployment.

Perhaps the most influential factor in after-deployment hospitalization rates has been greater access to health care after deployment (28–30). Unifying health and readiness policies under a strategy of Force Health Protection has signaled a movement toward more proactive health maintenance and injury and illness prevention. Unlike previous conflicts, returning personnel are screened in a primary health-care setting for illnesses potentially related to deployment. Screenings include assessments implemented to evaluate the mental and physical health of returning personnel and deployment-related exposures (29). Affirmative responses or deployment-related health concerns may result in referral for care. Heightened health awareness, multiple health screenings, easy access to health care providers, and subtle encouragement by military leaders to seek medical attention, may combine to increase the likelihood of after-deployment hospitalization.

Investigation of the three most frequently diagnosed after-deployment injuries and illnesses from each of the 14

broad diagnostic categories revealed the three most frequent diagnoses from certain broad diagnostic categories, such as musculoskeletal and mental disorders, were consistent with injuries or illnesses that may be found after deployment. Other categories such as neoplasms, found the most frequent diagnosis of uterine leiomyoma, which seems unlikely to be caused by deployment, but rather may be diagnosed more frequently after deployment. Categories including blood, nervous, and circulatory system diseases presented frequent diagnoses that may not have been previously considered as potentially associated with deployment yet warrant further investigation.

Studying the health effects of deployment has unique challenges because service members selected for deployment may be healthier than those who are not selected to deploy. Figure 1 documents healthy deployed personnel who may be selected to deploy by military procedures or selected out from deployment for injury or illness close to the time of deployment. For a period after deployment, it is reasonable that many hospitalizations may be attributable to injuries directly related to deployment or delayed elective medical procedures. The monthly hospitalization rates of deployers and regular active-duty personnel converge after about 1 year after deployment, possibly indicating a volume of delayed elective care that was accessed after deployment. This finding may also indicate that service members who are hospitalized in the year after deployment are more likely to separate from active service. Alternatively, it may reflect a trend toward normal active-duty military population levels of hospitalization.

These analyses have limitations that should be considered. Deployment itself is a broad measure of exposure.

TABLE 5. Frequency of the three most common diagnoses among diagnostic categories found to be associated with increased risk of after-deployment hospitalization when compared with before-deployment hospitalization

ICD-9-CM	Diagnoses	n (% ^a)
Infectious and parasitic diseases (codes 001–139)		
041	Bacterial infection in conditions elsewhere and of unspecified site	672 (44.0)
054	Herpes simplex	107 (7.0)
047	Meningitis due to enterovirus	105 (6.9)
Neoplasm (codes 140–239)		
218	Uterine leiomyoma	200 (26.5)
196	Secondary and unspecified malignant neoplasm of lymph nodes	31 (4.1)
186	Malignant neoplasm of testis	30 (4.0)
Endocrine, nutritional, and metabolic diseases (codes 240–279)		
276	Disorders of fluid, electrolyte, and acid-base balance	622 (36.9)
272	Disorders of lipid metabolism	406 (24.1)
250	Diabetes mellitus	128 (7.6)
Blood diseases (codes 280–289)		
285	Other/unspecified anemias	578 (50.5)
280	Iron deficiency anemia	139 (12.2)
287	Purpura and other hemorrhagic conditions	99 (8.7)
Mental disorders (codes 290–319)		
305	Nondependent abuse of drugs	2,012 (31.6)
309	Adjustment reaction	1,150 (18.1)
296	Episodic mood disorders	745 (11.7)
Nervous system diseases (codes 320–389)		
346	Migraine	200 (18.7)
348	Other conditions of brain	68 (6.4)
354	Mononeuritis of upper limb and mononeuritis multiplex	64 (6.0)
Circulatory diseases (codes 390–459)		
401	Essential hypertension	796 (36.6)
427	Cardiac dysrhythmias	268 (12.3)
453	Other venous embolism and thrombosis	118 (5.4)
Respiratory system diseases (codes 460–519)		
518	Other diseases of the lung	329 (17.5)
493	Asthma	297 (15.8)
486	Pneumonia, organism unspecified	209 (11.1)
Digestive system diseases (codes 520–579)		
540	Acute appendicitis	675 (18.4)
530	Diseases of esophagus	575 (15.6)
524	Dentofacial anomalies, including malocclusion	212 (5.8)
Genitourinary system diseases (codes 580–629)		
599	Other disorders of urethra and urinary tract	257 (13.1)
592	Calculus of kidney and ureter	190 (9.7)
614	Inflammatory disease of ovary, fallopian tube, pelvic cellular tissue, and peritoneum	122 (6.2)
Skin diseases (codes 680–709)		
682	Other cellulitis and abscess	559 (53.5)
685	Pilonidal cyst	67 (6.4)
709	Other disorders of skin and subcutaneous tissue	58 (5.6)
Musculoskeletal system diseases (codes 710–739)		
722	Intervertebral disc disorder	750 (18.0)
724	Other and unspecified disorders of back	439 (10.5)
717	Internal derangement of knee	415 (10.0)
Symptoms, signs and ill-defined conditions (codes 780–799)		
786	Symptoms involving respiratory system and other chest symptoms	846 (21.7)
780	General symptoms	808 (20.7)
789	Other symptoms involving abdomen and pelvis	529 (13.6)
Injury and poisoning (codes 800–999)		
998	Other complications of procedure, not elsewhere classified	462 (5.4)
959	Injury, other and unspecified	324 (3.8)
824	Fracture of ankle	285 (3.3)

^aPercentage of diagnostic category.

Studies of more specific deployment exposures as well as studies that are able to differentiate combat and noncombat deployments should be pursued. The study population was restricted to individuals with at least 1 year of continuous service before first deployment, thereby excluding a proportion of deployed service members, mostly consisting of young Marines and other soldiers who deploy quickly after enlisting. Thus, these results may not be characteristic of all deployed service members. In addition, because complete availability of hospitalization data is limited to active-duty personnel, we were unable to analyze Reserve or National Guard members or individuals who separated from service shortly after deployment. Further, excluding those who deployed within 1 year after returning from first deployment may have biased these results by removing healthier individuals. The use of hospitalization data to measure morbidity also restricted our analyses to health problems severe enough to require hospitalization and may not be a true measure of morbidity for categories such as mental health (31, 32). Further, the use of diagnostic coding for conditions such as cancer with a high-level of “rule-out” diagnosing by

providers, is inherently limited. Finally, this investigation focused on time until first hospitalization and not multiple hospitalizations for the same ICD-9-CM code, and may have missed information regarding illness severity.

Despite these limitations, this study also possesses a number of strengths. This analysis is the first to characterize a broad range of health problems among those deployed in support of the wars in Iraq and Afghanistan. Rather than focusing on one health condition, this study explored health conditions within all 14 major ICD-9-CM diagnostic categories and further determined the top three diagnoses driving all significant associations. Hospitalization data from all DoD hospitals worldwide and civilian providers billing to the DoD are considered very complete for active-duty personnel and were used for this study as an objective measure of health.

Debate over the appropriate comparison population for deployers has been often contentious (33), which encouraged a dual comparison investigation in these analyses of deployed personnel within the framework of before and after deployment as well as with a nondeployed population. This

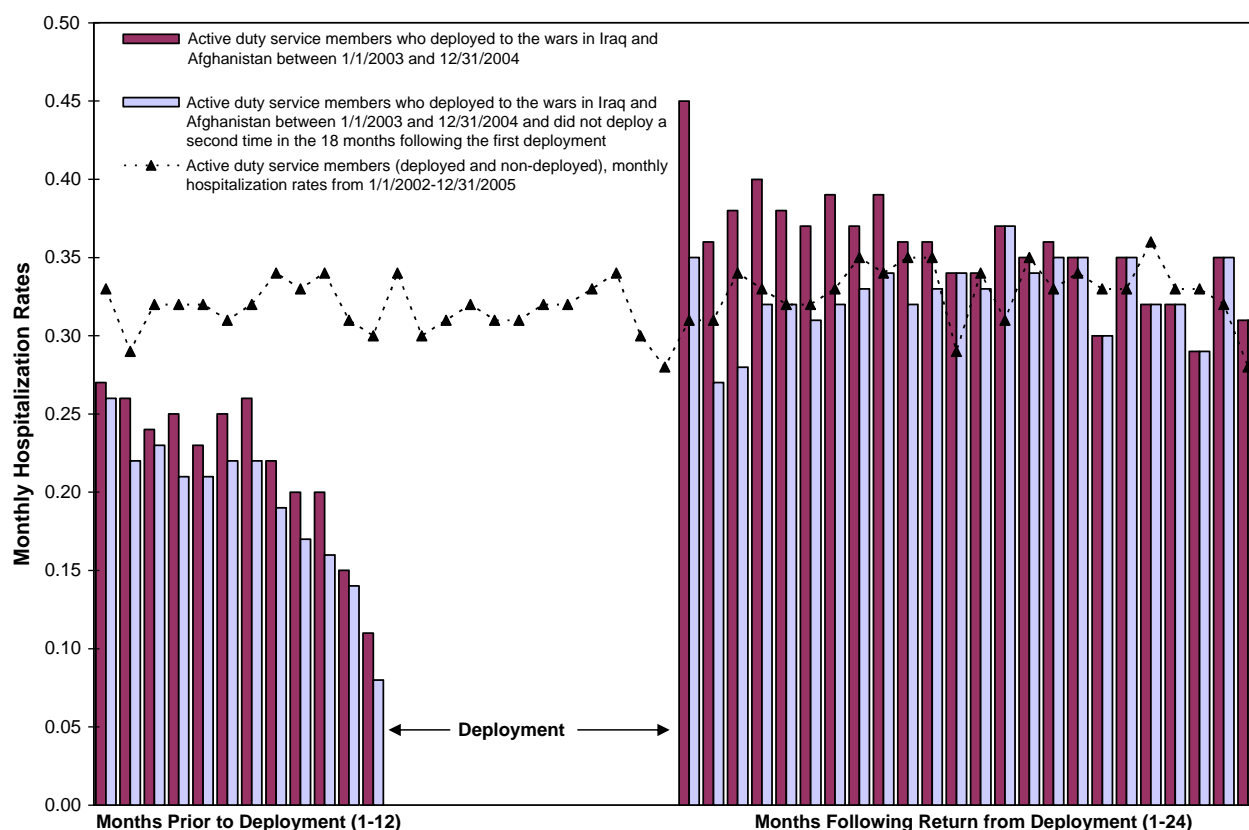


FIGURE 1. Monthly hospitalization rates for any cause, excluding child-bearing reasons, during the period of January 1, 2002, through December 31, 2005, among regular active-duty service members. Monthly hospitalization rates for any cause, excluding childbearing reasons, during the 12 months before and the 24 months after deployment in support of the wars in Iraq and Afghanistan among service members deployed for the first time between January 1, 2003, and December 31, 2004, and a subset of those service members who were active duty without a second deployment 18 months after deployment.

offers a unique investigation of after-deployment hospitalization risk that has not been done on a large population-base previously. The use of Cox's proportional hazards modeling provided effect estimates while adjusting for demographic and occupational variables and varying follow-up times. Finally, the large study population allowed sufficient statistical power to detect small differences.

In summary, these exploratory analyses demonstrate important factors associated with hospitalization after deployment and an increased risk of hospitalization in active-duty service members after deployment compared with before deployment but a lower risk when compared with nondeployers. Deployed personnel exhibited lower rates of before-deployment hospitalization than the general active-duty military, which became consistent with rates of the general active-duty military after return from deployment. Increased risk of hospitalization over a diverse set of health outcomes does not suggest a single etiology of health problems associated with deployment. This increase may be explained by a significant health care shift after the 1991 Gulf War, including after-deployment screening and pressure on military leaders to encourage medical evaluation among deployers for conditions they may have previously dismissed. More research using longitudinal data, such as in the Millennium Cohort Study (34), is necessary to investigate the long-term impact of combat deployments on the health of US military personnel.

We thank Scott L. Seggerman and Greg D. Boyd from the Defense Manpower Data Center, Seaside, California, for providing a sample of military personnel and their demographic and deployment data. We thank Michelle Stoia, from the Naval Health Research Center, San Diego, California, for editorial assistance. We appreciate the support of the Henry M. Jackson Foundation for the Advancement of Military Medicine, Rockville, Maryland.

REFERENCES

- Gray GC, Gackstetter GD, Kang HK, et al. After more than 10 years of Gulf War veteran medical evaluations, what have we learned? *Am J Prev Med.* 2004;26:443–452.
- Gray GC, Coate BD, Anderson CM, et al. The postwar hospitalization experience of US veterans of the Persian Gulf War. *N Engl J Med.* 1996;335:1505–1513.
- Smith TC, Corbeil TE, Ryan MA, et al. In-theater hospitalizations of US and allied personnel during the 1991 Gulf War. *Am J Epidemiol.* 2004;159:1064–1076.
- Gray GC, Smith TC, Kang HK, et al. Are Gulf War veterans suffering war-related illnesses? Federal and civilian hospitalizations examined, June 1991 to December 1994. *Am J Epidemiol.* 2000;151:63–71.
- Knoke JD, Gray GC. Hospitalizations for unexplained illnesses among U.S. veterans of the Persian Gulf War. *Emerg Infect Dis.* 1998;4:211–219.
- Dlugosz LJ, Hocter WJ, Kaiser KS, et al. Risk factors for mental disorder hospitalization after the Persian Gulf War: U.S. Armed Forces, June 1, 1991–September 30, 1993. *J Clin Epidemiol.* 1999;52:1267–1278.
- Knoke JD, Gray GC, Garland FC. Testicular cancer and Persian Gulf War service. *Epidemiology.* 1998;9:648–653.
- Smith TC, Gray GC, Knoke JD. Is systemic lupus erythematosus, amyotrophic lateral sclerosis, or fibromyalgia associated with Persian Gulf War service? An examination of Department of Defense hospitalization data. *Am J Epidemiol.* 2000;151:1053–1059.
- Smith TC, Jimenez DL, Smith B, et al. The postwar hospitalization experience of Gulf War veterans participating in US health registries. *J Occup Environ Med.* 2004;46:386–397.
- Gackstetter GD, Hooper TI, Al Qahtani MS, et al. Assessing the potential health impact of the 1991 Gulf War on Saudi Arabian National Guard soldiers. *Int J Epidemiol.* 2005;34:801–808.
- Hooper TI, Smith TC, Gray GC, et al. Saudi Arabia–United States collaboration in health research: a formula for success. *Am J Infect Control.* 2005;33:192–196.
- Smith TC, Heller JM, Hooper TI, et al. Are veterans of the Gulf War experiencing illness from exposure to Kuwaiti oil well fire smoke? Department of Defense hospitalization data examined. *Am J Epidemiol.* 2002;155:908–917.
- Smith TC, Gray GC, Weir JC, et al. Gulf War veterans and Iraqi nerve agents at Khamisiyah. Postwar hospitalization data revisited. *Am J Epidemiol.* 2003;158:456–467.
- Gray GC, Smith TC, Knoke JD, et al. The postwar hospitalization experience of Gulf War Veterans possibly exposed to chemical munitions destruction at Khamisiyah, Iraq. *Am J Epidemiol.* 1999;150:532–540.
- Hoge CW, Castro CA, Messer SC, et al. Combat duty in Iraq and Afghanistan, mental health problems, and barriers to care. *N Engl J Med.* 2004;351:13–22.
- Hoge CW, Auchterlonie JL, Milliken CS. Mental health problems, use of mental health services, and attrition from military service after returning from deployment to Iraq or Afghanistan. *JAMA.* 2006;295:1023–1032.
- Smith TC, Ryan MA, Wingard DL, et al. New onset and persistent symptoms of post-traumatic stress disorder self reported after deployment and combat exposures: prospective population based US military cohort study. *BMJ.* 2008;336:366–371.
- Hotopf M, Hull L, Fear NT, et al. The health of UK military personnel who deployed to the 2003 Iraq war: a cohort study. *Lancet.* 2006;367:1731–1741.
- Jacobson IG, Ryan MA, Hooper TI, et al. Alcohol use and alcohol-related problems before and after military combat deployment. *JAMA.* 2008;300:663–675.
- Smith B, Ryan MA, Wingard DL, et al. Cigarette smoking and military deployment: a prospective evaluation. *Am J Prev Med.* 2008;35:539–546.
- Iversen A, Waterdrinker A, Fear N, et al. Factors associated with heavy alcohol consumption in the U.K. armed forces: data from a health survey of Gulf, Bosnia, and era veterans. *Mil Med.* 2007;172:956–961.
- The International Classification of Diseases, 9th Revision, Clinical Modification. Salt Lake City: Medicode Publication; 1998.
- Wei L, Lin D, Weissfeld L. Regression analysis of multivariate incomplete failure time data by modeling marginal distributions. *J Am Stat Assoc.* 1989;84:1065–1073.
- Hyams KC, Wignall FS, Roswell R. War syndromes and their evaluation: From the U.S. Civil War to the Persian Gulf War. *Ann Intern Med.* 1996;125:398–405.
- Jones E, Hodgins-Vermaas R, McCartney H, et al. Post-combat syndromes from the Boer War to the Gulf War: A cluster analysis of their nature and attribution. *BMJ.* 2002;324:321–324.
- Smith B, Smith TC, Ryan MA, et al. A comparison of the postdeployment hospitalization experience of U.S. military personnel following service in the 1991 Gulf War, Southwest Asia after the Gulf War, and Bosnia. *J Occup Environ Hyg.* 2006;3:660–670.
- Gray GC, Knoke JD, Berg SW, et al. Counterpoint: Responding to suppositions and misunderstandings. *Am J Epidemiol.* 1998;148:328–333.
- Mazzuchi JF, Claypool RG, Hyams KC, et al. Protecting the health of U.S. military forces: a national obligation. *Aviat Space Environ Med.* 2000;71:260–265.

29. Hyams KC, Riddle J, Trump DH, et al. Protecting the health of United States military forces in Afghanistan: applying lessons learned since the Gulf War. *Clin Infect Dis*. 2002;34:S208–214.
30. Trump DH, Mazzuchi JF, Riddle J, et al. Force health protection: 10 years of lessons learned by the Department of Defense. *Mil Med*. 2002;167:179–185.
31. Hoge CW. Re: 'Psychiatric diagnoses in historic and contemporary military cohorts: combat deployment and the healthy warrior effect. *Am J Epidemiol*. 2008;168:1095–1096 author reply 6–8.
32. Smith TC, Ryan MA, Smith B, et al. Re: "Psychiatric diagnoses in historic and contemporary military cohorts: combat deployment and the healthy warrior effect." *Am J Epidemiol*. 2008;168:1094–1095; author reply 6–8.
33. Wilson J, Jones M, Fear NT, et al. Is previous psychological health associated with the likelihood of Iraq war deployment? An investigation of the healthy warrior effect. *Am J Epidemiol*. 2009;169:1362–1369.
34. Ryan MA, Smith TC, Smith B, et al. Millennium Cohort: enrollment begins a 21-year contribution to understanding the impact of military service. *J Clin Epidemiol*. 2007;60:181–191.

REPORT DOCUMENTATION PAGE

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB Control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**

1. Report Date (DD MM YY) 14/06/07		2. Report Type New		3. DATES COVERED (from - to) 2003-2005	
4. TITLE AND SUBTITLE Postdeployment Hospitalizations Among Service Members Deployed in Support of the Operations in Iraq and Afghanistan				5a. Contract Number: 5b. Grant Number: 5c. Program Element: 5d. Project Number: 5e. Task Number: 5f. Work Unit Number: 60002	
6. AUTHORS Tyler C. Smith, MS, PhD; Cynthia A. Leard, MPH; Besa Smith, MPH, PhD; Isabel Jacobson, MPH; and Margaret A.K. Ryan, MD, MPH					
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Health Research Center P.O. Box 85122 San Diego, CA 92186-5122					
8. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES) Commanding Officer Commander Naval Medical Research Center Navy Medicine Support Command 503 Robert Grant Ave P.O. Box 240 Silver Spring, MD 20910-7500 Jacksonville, FL 32212-0140				9. PERFORMING ORGANIZATION REPORT NUMBER Report No. 07-26	
				10. Sponsor/Monitor's Acronyms(s) NMRC/NMSC	
				11. Sponsor/Monitor's Report Number(s)	
12 DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited.					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT (maximum 200 words) Context There is growing public and veteran concern over the health impact of military deployments to Iraq and Afghanistan. Objectives This exploratory investigation compares postdeployment and predeployment morbidity, as measured by hospitalization. Design, Setting, and Participants Regular, active-duty military personnel who deployed for the first time in support of the Global War on Terrorism between January 1, 2003, and December 31, 2004, returned from deployment before July 1, 2005, and had at least 12 months of service prior to deployment were included in these analyses. Methods This historical prospective investigation utilized Cox's proportional hazards time-to-event modeling while taking into account the correlation of outcomes within subjects. Main Outcome Measures Hospitalizations for any cause and hospitalizations based on 14 broad diagnostic categories. Results: After adjusting for demographic and military variables, the postdeployment risk for any cause hospitalization (HR, 1.57; 95% CI, 1.49-1.66) and all 14 broad ICD-9-CM categories was greater in comparison with predeployment risk. Conclusions: The increased risk of hospitalization over a diverse set of outcomes does not suggest a single etiology of morbidity associated with recent deployment. More prospective analyses are necessary to investigate the long-term health impact of military deployments.					
15. SUBJECT TERMS hospitalization, military medicine, military personnel, veterans, Iraq, Afghanistan					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UNCL	18. NUMBER OF PAGES 10	19a. NAME OF RESPONSIBLE PERSON Commanding Officer
a. REPORT UNCL	b. ABSTRACT UNCL	b. THIS PAGE UNCL			19b. TELEPHONE NUMBER (INCLUDING AREA CODE) COMM/DSN: (619) 553-8429